WE CLAIM:

1. A method of identifying an extreme interaction pitch region when designing a mask pattern for transferring a lithographic pattern onto a substrate by use of a lithographic apparatus, said method comprising the steps of:

(a) determining an illumination intensity for a first pitch and a first illumination angle,

(b) determining an illumination intensity for said first pitch and a second illumination angle, said second illumination angle being rotationally symmetric with respect to said first illumination angle,

(c) determining a total illumination intensity for said first pitch by combining the illumination intensity associated with said first illumination angle and said second illumination angle,

(d) determining the log-slope of said total illumination intensity, and

(e) identifying a pitch region containing said first pitch as an extreme interaction pitch region if the value of the derivative of the log-slope of said total illumination intensity with respect to pitch is approximately equal to zero.

2. A method according to claim 1, further comprising the steps of:
repeating steps (a)-(e) for a plurality of different pitches.

3. A method according to claim 2 further comprising repeating steps (a) – (e) for a plurality of illumination angles and wherein a pitch is identified as an extreme interaction pitch region if the value of the derivative of the log-slope of said total illumination intensity with respect to pitch is approximately equal to zero for each of said plurality of illumination angles.

4. A method according to claim 1, wherein said second illumination angle exhibits a 90 degree rotational symmetry with respect to said first illumination angle.

5. A method according to claim 1, wherein said pitch region is a range of pitches within +/- 0.12 x λ/NA of a specified pitch, wherein λ is the wavelength of the exposure radiation of said lithographic apparatus and NA is the numeric aperture of the projection system of said lithographic apparatus.

6. A method according to claim 1, further comprising the steps of:

for a given pitch identified as being in an extreme interaction pitch region:

(f) determining an illumination intensity for said given pitch and a first illumination angle,

(g) determining an illumination intensity for said given pitch and a second illumination angle, said second illumination angle being rotationally symmetric with respect to said first illumination angle,

(h) determining a second total illumination intensity for said given pitch by combining the illumination intensity associated with said first illumination angle and said second illumination angle,

(i) determining the log-slope of said second total illumination intensity,

(j) identifying a given illumination angle as being undesirable for said given pitch if said log-slope of said second total illumination intensity is less than a predetermined value, and

(k) repeating steps (f)-(j) for a plurality of different illumination angles.

7. A method according to claim 6 wherein said predetermined value is 15.

8. A method of designing a mask pattern for transferring a lithographic pattern onto a substrate by use of a lithographic apparatus with a desired illumination scheme, said method comprising:

identifying extreme interaction pitch regions and corresponding undesirable illumination angles according to the method of claim 6; and

designing said mask pattern by arranging features such that no combination of features in said mask pattern has a pitch in an extreme interaction pitch region for which illumination angles in said desired illumination scheme are undesirable.

9. A method according to claim 8 wherein said mask pattern includes main features and optical proximity correction elements and said step of designing includes positioning said optical proximity correction elements so as not to create pitches between main features and optical proximity correction elements that fall in an extreme interaction pitch region for which illumination angles in said desired illumination scheme are undesirable.

10. A method of manufacturing a mask comprising the steps of:
designing a mask pattern according to the method of claim 8; and
manufacturing a mask embodying the designed mask pattern.

11. A device manufacturing method comprising the steps of:

providing a substrate that is at least partially covered by a layer of radiation-sensitive material;

providing a projection beam of radiation using a radiation system;

using patterning means to endow the projection beam with a pattern in its cross-section;

projecting the patterned beam of radiation onto a target portion of the layer of radiation-sensitive material,

characterized by:

identifying extreme interaction pitch regions in said desired pattern according to the method of claim 1;

creating illumination maps for said extreme interaction pitch regions in said desired pattern, said illumination map comprising the log-shape of said total illumination intensity as a function of illumination angle; and

identifying favorable illumination angles from said illumination maps;

wherein in said step of providing a projection beam, said projection beam is arranged to illuminate said mask substantially only at angles identified as favorable illumination angles in all said illumination maps.

12. A method according to claim 11 wherein:

in said step of identifying extreme interaction pitch regions, at least first and second extreme interaction pitch regions are identified;

in said step of identifying favorable illumination angles, first and second sets of favorable illumination angles for said first and second extreme interaction pitch regions are identified; and

wherein said steps of providing a projection beam, using patterning means and projecting the patterned beam, are performed twice, once using said first set of favorable illumination angles and once using said second set.

13. A method according to claim 12 wherein said step of identifying favorable illumination angles comprises identifying the illumination angles having the highest values of log-shape of illumination intensity.

14. A method according to claim 11 wherein said step of identifying favorable illumination angles comprises identifying the illumination angles having a value of log-shape of illumination intensity higher than a predetermined amount.

15. A computer program comprising program code means that, when executed on a computer, instruct the computer to perform the method of claim 1.

16. A computer program comprising program code means that, when executed on a computer, instruct the computer to perform the method of claim 6.

17. A computer program comprising program code means for controlling a lithographic apparatus to perform the method of claim 11.

18. A method of identifying undesirable pitches between features when designing an integrated device to be formed on a substrate by use of a lithographic apparatus, said method comprising the steps of:

(a) identifying extreme interaction pitch regions by determining illumination intensity levels for a given illumination angle over a range of pitches; and

(b) identifying said undesirable pitches for each extreme interaction pitch region identified in step (a) by determining illumination intensities for a given extreme interaction pitch region over a range of illumination angles.

19. A method according to claim 18, wherein said extreme interaction pitch regions define regions which exhibit either substantial constructive optical interference or substantial destructive optical interference.

20. A method according to claim 18, wherein said undesirable pitches have corresponding illumination intensities exceeding a predetermined value.

21. A method according to claim 18, wherein said features comprise a main feature and an optical proximity correction element.